Correlation of Certain Physical and Chemical Changes in the Southern Pea, *Vigna sinensis*, with Six Stages of Maturity

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INTRODUCTION

The southern pea, *Vigna sinensis*, (L.) Savi, is a native of India and the region northwestward to the southern part of the Trans-Caspian area (40). It was introduced into the West Indies during the latter half of the Seventeenth Century, and into the mainland of North America at the beginning of the Eighteenth Century.

Vigna sinensis, is known by such common names as southern peas, cowpeas and blackeyed peas. Unfortunately, this frequently leads to the confusion of the southern pea with the English pea, *Pisum sativum*.

The southern pea has become an important source of food, especially in the southern states. Its importance and potentialities as a food crop are often underestimated. As may be noted in Plates I and II, this crop produces a good yield when grown under favorable growing conditions. Each year many tons of processed southern peas are shipped to distant markets as well as being utilized extensively in the areas where they are grown, and the demand is increasing as it becomes better known and appreciated. The southern pea also ranks high among other food products in certain compounds such as vitamins, proteins, and carbohydrates, which are essential for a balanced diet.

The degree of maturity of any vegetable when harvested greatly affects its quality. This fact is probably more important for southern peas than for most other crops of its type because of the rapidity with which the maturing process occurs. This effect upon quality is mainly caused by the many physical and chemical changes occurring during growth and development of the fruit. Cognizance of these changes should be of practical benefit

PLATE I

THE VARIETY CALIFORNIA NO. 5 BLACKEYE SOUTHERN PEA IN THE FIELD

PLATE II

A CLOSE UP VIEW OF THE VARIETY CALIFORNIA NO. 5
BLACKEYE SOUTHERN PEA

to the growers and handlers of vegetables in determining the optimum stage of maturity for harvesting in order to produce a quality product. It would aid in the understanding of some of the physiological processes taking place in the plant, and also furnish information which would be valuable in establishing an index of maturity.

Several methods have been devised and used with varying success for determining when a product has reached optimum maturity. This is especially true with respect to such popular crops as English peas, green beans, lima beans and sweet corn. However, little has been done toward establishing the extent of the various physical and chemical changes occurring in the southern pea during its development. Consequently, the potentialities of measuring these physical and chemical changes and establishing indices for the stages of maturity have remained uninvestigated.

This study was undertaken to determine the influence of maturity upon certain physical and chemical changes occurring in the southern pea and the possibilities of utilizing these changes as indices of the stage of development.

REVIEW OF LITERATURE

Although the southern pea has been grown and utilized as a food crop on the North American Continent, especially in the southern part of the United States, for over 200 years, relatively little experimental information is available on its composition and physical characteristics at various stages of maturity. In contrast, there have been many studies on the physical and chemical changes occurring during development in some of the other crops in the Papilionatae division of the Leguminosae family.

Makower (24) states that the tenderness and quality of a processed vegetable will depend largely on the physiological maturity of the raw vegetable which is in turn influenced by genetic, geographic and climatic factors.

According to Bisson and Jones (4) the advance in the development of English peas is characterized by an increase in starch, dry matter, hydrolyzable polysaccharides, and crude fiber, and a decrease in sucrose and total nitrogen content.

According to Makower (24) the specific gravity in English peas has been used fairly successfully for determining stages of maturity and their separation into different grades. He warns, however, that the determination of specific gravity is subject to two important errors, namely, the buoyancy of the air present in the whole pea and the changes in specific gravity in both the peas and the surrounding liquid during the measurements.

Some investigators have indicated that the amount of total solids might be used as an index of maturity. However, Kertesz (20) reported that total solids were somewhat unreliable as an index of maturity for raw English peas although they did increase with maturity. Jacobs (18) suggested that sucrose did not correlate well with maturity; nevertheless, it was a good indicator as to the proper time to harvest the crop for processing. Bisson and Jones (4) reported that English peas were not at the best size for harvesting when the percentage of sucrose was at its maximum, but that they were ready for harvest at the time when the total weight of sucrose in the fruit was at its highest.

Although the size of the English pea increases with maturity up to a point in its development, it is not a reliable index of maturity. The maturity of a given size depends on the variety of the pea, the location, conditions of harvesting as well as other factors (5) (24).

Alcohol-insoluble solids steadily increase with the ripening of the seeds of English peas, and have long been considered as a reliable measure of maturity (6) (19) (21) (24). According to Makower (24), Kertesz considers alcohol-insoluble solids a better measure of maturity for canned peas than total solids in spite of a considerable overlapping of the U.S. standard grades for the same alcohol-insoluble value.

In general, as the seed of lima beans mature there is a rapid increase in the starch content resulting in a firmer texture. The firmness finally reaches a point in the over-mature bean where it becomes highly undesirable and lowers the quality of the product. Accompanying the increase in starch content, there is a decrease in the moisture content with a corresponding increase in total solids and specific gravity (11).

Only limited use has been made of the changes in specific gravity of lima beans for separation into maturity stages, although Barton (7) showed in 1922 that specific gravity determinations could be employed as an index for maturity in sweet corn. In lima beans the use of specific gravity has been confined mainly to the removal of distinctly over-mature seeds from the less mature, and little attempt has been made to employ it for determination of grades. Culpepper and Magruder (11) found that the correlation of the specific gravity of the fresh entire lima bean seeds with stage of maturity was extremely poor, especially in the large-seeded variety and at the earlier stages of maturity. They observed that when the seed coats were removed the correlation between specific gravity of the naked cotyledons and stages of development was high. In the case of the entire seeds, the poor correlation was attributed to the presence of air beneath the seed coats and between the cotyledons.

Lee (23), in an investigation of maturity of frozen lima beans, suggested that since specific gravity, alcohol-insoluble solids and total solids increase with maturity, they could be used to denote not only the stage of maturity, but also quality.

Green beans, like other closely related crops of the Leguminosae family, possess certain characteristics which tend to change as the stage of maturity increases. The increase in maturity is characterized by an increase in the per cent seed of the total weight of the pod, diameter of seed, alcohol-insoluble solids, starch, total solids, and fiber content. According to Stark and Mahoney (38) this increase in fiber content of the side wall is the most important factor which influences the edible quality of the green bean.

The per cent seed content of the green bean increases in a straight line relationship with advancing maturity (9). Not only is the per cent seed of the pod a good index of the stage of maturity, but it is also indicative of quality. For example, the Food and Drug Administration is responsible for setting up minimum standards of quality for products which may be shipped through interstate commerce without labeling, "Below minimum standard of quality-----------". They set a maximum limit of 25 per cent seeds and pieces of seeds of the total trimmed pods as one of their criteria for minimum quality (16).

Gould (16) made an evaluation of quality of fresh, frozen, and canned green beans. He placed the per cent seeds of the green bean at optimum maturity between 8.1 and 16.0 per cent. At optimum maturity, he found that the total solids of fresh beans were 9.65 per cent, frozen 8.92 per cent, and canned green beans 7.83 per cent. He further concluded that the alcohol-insoluble solids at the optimum stage of maturity were 3.48 per cent for fresh, 3.30 per cent for frozen, and 2.14 per cent for canned green beans, on a fresh weight basis.

In the southern pea previous studies indicate that the ascorbic acid content changes with maturity. However, these investigations of ascorbic acid, like those for the determination of other compounds, were limited to not more than three stages of maturity. Mitchel and Roderick (26) reported an average ascorbic acid content of 70.50 milligrams per 100 grams of seeds for six varieties of green shelled peas and 222.78 milligrams per 100 grams of pods in the snap stage of southern peas. Richardson et al. (3) reported an average of 53.3 milligrams ascorbic acid per 100 grams of seeds on a dry weight basis and 21.7 milligrams per 100 grams seed, on a fresh weight basis, for four varieties of green shelled peas. Sheets and

Sholes (13) found 124.6 milligrams of ascorbic acid per 100 grams of seed in immature cowpeas. Reid (29) reported 20.8 milligrams ascorbic acid per 100 grams of seed in ripening seeds, but found only a trace, if any, in the dry seeds of cowpeas. French and Abbott (14) in determining the levels of ascorbic acid in Florida-grown foods found that southern peas contained an average ascorbic acid content of 45 milligrams per 100 grams of seeds for two varieties. Munsell *et al.* (27) found 18.0 milligrams ascorbic acid per 100 grams of seed for cowpeas grown in Central America. Watt and Merrill (39) reported 31.0 milligrams of ascorbic acid per 100 grams of immature seeds, on a fresh weight basis, and 2.0 milligrams per 100 grams for mature dry southern peas.

Nicotinic acid also appears to vary with maturity in southern peas; however, this variation is not as great as that found for ascorbic acid. Richardson *et al.* (30) reported an average of 1.01 milligrams nicotinic acid per 100 grams of seeds in southern peas at the snap stage, on a fresh weight basis, 1.73 milligrams per 100 grams of seeds in green shelled peas, and 2.00 milligrams per 100 grams of seeds in mature peas. Watt and Merrill (39) reported 0.9 milligrams of nicotinic acid per 100 grams of immature seeds, on a fresh weight basis, and 2.2 milligrams per 100 grams of mature dry seeds. French, Abbott and Townsend (15) investigated the levels of nicotinic acid in Florida-produced foods and reported an average of only 0.96 milligrams per 100 grams of southern pea seeds, on a fresh weight basis.

Mitchel and Roderick (26) investigated the starch content of six varieties of southern peas in three stages of maturity and found an average of 20.55 per cent in the snap stage, 46.08 per cent for green-shelled seeds, and 49.60 per cent for mature-shelled seeds. Sarin and Qureshi (32) reported that they found 39.20 per cent starch in southern peas, but gave no indication as to the stage of development of the peas in their investigation.

Watt and Merrill (39) reported an average of 9.4 per cent protein content in immature seeds of southern peas, on a fresh weight basis, and 22.9 per cent in mature dry seeds. Richardson (31) investigated the protein content of three varieties of southern peas and reported an average of 25.8 per cent. Sherman (34) found an average of 21 per cent protein in southern peas and further stated that the protein of soybeans was superior to the protein in southern peas as a food product when tested with rats. Sarin and Qureshi (32) stated that they found an average of 28.81 per cent protein in southern peas. Mitchel and Roderick (26) reported, in a study of southern peas at three stages of maturity, an average of 24.40 per cent protein in the snap stage, 24.96 per cent in the green-shelled peas, and 26.03 per cent in mature-shelled peas.

No evidence was found to indicate that the specific gravity, conductivity of extract, refractive index, per cent seed shellout, alcohol-insoluble solids or sugars have been previously determined for southern peas at different stages of maturity.

METHODS AND PROCEDURES

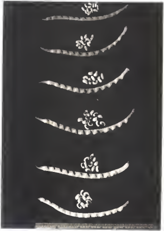
Three plantings were made at intervals of approximately two weeks during March and April, 1951 and 1952, in order to study the effect of certain environmental conditions upon the physiological characteristics of southern peas during their growth and development. The southern pea variety California Blackeye No. 5 was used in this experiment. Standard cultural practices were followed. A fairly constant soil moisture level was maintained during the development of the crop by the use of irrigation.

During 1952 a continuous record of the temperature was maintained from the first planting date until the last harvest. Only the mean temperature was available for the 1951 season. This was determined by taking the average between the high and low temperature for each 24 hour period.

In order to harvest samples at the six different stages of maturity shown in Plate III, 100 blooms were tagged at random in each of the plantings and their date of flowering recorded. Pods which developed from these flowers were used as a guide in harvesting the samples of the various stages of maturity. When the tagged pods developed to the point where the seeds could be separated from the pericarp manually, the first harvests were made. This was the first stage of maturity and successive harvests were made at two-day intervals until the sixth or last stage was harvested. During the 1951 season twelve days were required between tagging of the flowers and the harvesting of the first stage of maturity in the first planting. Ten days were required for the second and third planting. In the 1952 season nine days elapsed between tagging of the

PLATE III

SOUTHERN PEAS AT SIX STAGES OF MATURITY
PROGRESSING FROM TOP TO BOTTOM



flowers and the harvesting of the first stage of maturity in the first and second plantings. Ten days were required for the third planting. Therefore, in this study ten days were considered as the time required for peas to reach the first stage of maturity after flowering. From the first stage of maturity to the fourth stage, sixteen days after flowering, the pods retained their green color. After the fourth stage, there appeared to be a slight decrease in the size of the seeds, but no measurements were made. The increase in the seeds followed by a slight decrease may be noted in Plate III. The slight decrease in the size of the seeds was accompanied by a rapid loss in the green color from the pods. All green color had completely disappeared from the pods by the time the southern peas had reached the sixth stage, 20 days after flowering.

Immediately upon harvesting, the peas were brought to the laboratory and held at 40° F until samples for the various determinations could be shelled and prepared. There was never a time lapse of more than six hours between the time the peas were harvested and the preparation of samples for the different determinations.

The moisture content was determined by drying 100 grams of freshly shelled seeds in a vacuum oven at 70 degrees C. Ascorbic acid was determined by the indophenol method described by Bessey (3) as modified by Menaker and Guerrant (25). Nicotinic acid was determined by the microbiological technique described by Snell (37), with the modification that Difco dehydrated assay media were substituted for the formula recommended by Snell. The protein content was determined by the micro-Kjeldahl method described in the A.O.A.C. for total nitrogen (1). The nitrogen was multiplied by the factor 6.25 to obtain the protein content. Alcohol-insoluble solids were determined by the method recommended by the A.O.A.C. (2). Total and reducing sugars were determined by the Shaffer-Somogyi method (17) as adapted to the determination of sugars in sweet corn by Showalter (35). Starch content was determined by digesting the alcohol-insoluble residue with taka-diastase for twenty-four hours at 38° C and subsequent acid hydrolysis to form glucose. The Shaffer-Somogyi method was followed for determining the glucose. The per cent seed shellout was determined by taking 100 grams of unshelled pods, shelling, and weighing the seeds. The specific gravity was determined by the method of Nichols and Reed (3) with the modification that alcohol was substituted for xylene. Specific gravity was determined before and after the seeds were blanched for three minutes in boiling water and cooled. The determination of the specific gravity of both blanched and unblanched seeds was complicated by gas bubbles adsorbed on the surface of the seeds which caused the apparent specific gravity to be less than its true value, due to the buoying action of the air bubbles. This was evident by the fact that when the bubbles became detached from the seeds with time, the specific gravity increased. Because of this phenomenon, care had to be exercised in weighing the samples for the same length of time after lowering the seeds into the weighing medium in order to obtain greater precision in arriving at a relative measurement of specific gravity. Seeds which were blanched did not appear to have so many gas bubbles adsorbed on their surface, thus partially eliminating the error caused by their buoyancy. Samples for determination of the refractive index and specific conductance was prepared by freezing the seeds and subsequent extraction of the juice with a Carver laboratory press. The refractive index of the juice was determined with an Abbé refractometer. The specific conductance was determined with a Solu specific conductance bridge.

Samples of each stage of maturity were prepared for the organoleptic examination by shelling, blanching for three minutes in boiling water, and freezing in an eight-ounce tall can at 0° F. The peas were held at this temperature until the organoleptic examination was made approximately six months later. The day the samples were to be examined by the taste panel, they were removed from storage and allowed to thaw. After thawing, the samples were opened and cooked by boiling in a 2 per cent sodium chloride solution for 15 minutes. The taste panel consisted of students from Dr. Stout's Food Processing Class, secretaries, and laboratory technicians from the Vegetable Products Laboratory of the Florida Agricultural Experiment Station. Samples representing southern peas of the various stages of maturity were rated by the taste panel as followed: 0 - 4 poor; 4 - 6 fair; 6 - 8 good and 8 - 10 excellent. Samples representing all six stages of maturity were examined at the same time and were rated for general appearance, color, texture, flavor and odor.

The data were first analyzed by the analysis of variance technique. The variance attributed to maturity was partitioned between that associated with the linear, curvilinear, and deviation from the quadratic responses (36). In all instances the linear regression and correlation coefficients for the relationships of the various physical and chemical changes to maturity were determined. If the curvilinear response of these physical and chemical changes to maturity was shown to be significant by the analysis of variance test, the curvilinear regression and correlation coefficients were also determined.

EXPERIMENTAL RESULTS

Influence of Maturity Upon the Moisture Content

1951 Season.- There was a decrease in the moisture content of the seeds of southern peas from 82.8 per cent in the first stage of maturity to 57.5 per cent in the sixth stage as shown by the data presented in Table 1. This decline represented an average decrease of approximately 2.5 per cent per day from the time the first stage was harvested until the harvesting of the sixth stage. There was an acceleration in the loss of moisture between stages four and five which coincided with a change in the color of the pods from a green to a yellowish-green. The average moisture content for the southern peas harvested from any one planting was very close to the moisture content in the other two plantings for similar stages of maturity.

The decrease in the moisture content of southern peas with maturity was highly significant (Table 1a). According to the least significant difference (L.S.D.) given in Table 1, the variations among all stages of maturity were highly significant. No significant differences in moisture content existed among southern peas harvested from different planting dates. Although the curvilinear regression line (Figure 1) formed the best fit, the departure of the average moisture content from linearity was not great.

1952 Season.- Results presented in Table 2 show that the moisture content of the seeds of southern peas decreased with maturity from 83.9 per cent in the first stage to 74.0 per cent in the third stage. After reaching 74.0 per cent in the third stage, there was a sharper decline

TABLE 1

MOISTURE CONTENT OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings First	Plantings Second	Plantings Third	Means for Stages
	%	%	%	%
1	82.00	82.70	83.70	82.80
2	79.70	77.88	78.50	78.69
3	74.62	74.14	74.35	74.37
4	69.85	69.12	70.24	69.74
5	60.20	63.50	61.72	61.81
6	56.30	58.89	57.48	57.56
Means for Plantings	70.44	71.04	71.00	

L.S.D. for Stage of Maturity Means .05 = 1.965

L.S.D. for Stage of Maturity Means .01 = 2.766

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.989

Curvilinear Correlation Coefficient = 0.992

TABLE 2

MOISTURE CONTENT OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, 1952

Stage of Maturity	Plantings First	Plantings Second	Plantings Third	Means for Stages
	%	%	%	%
1	84.56	83.46	83.70	83.91
2	83.70	78.08	79.36	80.38
3	75.24	73.09	73.82	74.05
4	68.25	68.67	65.70	67.54
5	62.80	61.24	60.21	61.42
6	56.50	48.14	46.11	50.25
Means for Plantings	71.84	68.78	68.15	

L.S.D. for Stage of Maturity Means .05 = 2.142

L.S.D. for Stage of Maturity Means .01 = 2.885

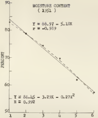
L.S.D. for Planting Means .05 = 1.551

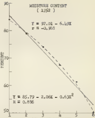
L.S.D. for Planting Means .01 = 2.574

Linear Correlation Coefficient = -0.972

Curvilinear Correlation Coefficient = 0.886

Figure 1. The linear and curvilinear relationships of moisture content to the maturity of southern peas during 1951-1952.


MOISTURE CONTENT
(1951)
Y = 88.97 - 5.18X
r = -0.989
Y = 86.45 - 3.29X - 0.27X²
R = 0.992
PERCENT
90
80
70
60
50
1
2
3
4
5
6
STAGE OF MATURITY


MOISTURE CONTENT
(1952)
Y = 92.01 - 6.49X
r = -0.988
Y = 85.79 - 2.06X - 0.63X²
R = 0.886
PERCENT
90
80
70
60
50
1
2
3
4
5
6
STAGE OF MATURITY

in moisture with each succeeding stage until 50.2 per cent remained in the sixth stage of maturity. This represented an overall average decrease of approximately 3.4 per cent moisture per day during the period between the harvesting of the first and sixth stages of maturity.

An analysis of the data (Table 2a) indicates that the decrease in moisture with maturity was highly significant. The L.S.D. (Table 2) gives evidence that the differences among all stages of maturity were also highly significant. The variance associated with planting dates was highly significant; however, no significant difference in moisture existed between the second and third plantings. The departure of the average moisture content from linearity was small (Figure 1).

The Influence of Maturity Upon the Alcohol-Insoluble Solids Content

Fresh Weight.- The alcohol-insoluble solids increased in an almost straight-line relationship with maturity from 12.7 per cent in the first stage to 37.0 per cent in the sixth stage (Table 3). This increase with maturity represented an average of approximately 2.5 per cent per day. A relatively sharp increase in the alcohol-insoluble solids occurred when the pericarp began to change from a green color in stage four to a yellowish-green in stage five. This accelerated rate of accumulation did not continue after the fifth stage, but instead, began to level off.

Analysis of the data (Table 3a) showed that this increase in the alcohol-insoluble solids content with maturity was highly significant. The L.S.D. (Table 3) indicated there were highly significant differences among all stages of maturity. When a linear regression line was fitted

TABLE 3

ALCOHOL-INSOLUBLE SOLIDS CONTENT OF SOUTHERN PEAS, ON A FRESH WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	12.31	12.73	13.00	12.68
2	16.28	16.93	17.45	16.88
3	21.91	22.04	21.28	21.74
4	25.64	27.37	25.53	26.18
5	35.37	34.11	33.82	34.43
6	38.74	35.69	36.65	37.02
Means for Plantings	25.04	24.12	24.62	

L.S.D. for Stage of Maturity Means .05 = 1.717

L.S.D. for Stage of Maturity Means .01 = 2.443

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.989

Curvilinear Correlation Coefficient N.S.

to the average alcohol-insoluble solids content at different stages of maturity (Figure 2), there appeared to be a good fit with little departure from this line.

Dry Weight:- There was an increase in the alcohol-insoluble solids with maturity from 74.0 per cent in the first stage of development to a high of 90.2 per cent in the fifth stage (Table 4). A slight decrease occurred between the fifth and sixth stages of maturity from 90.2 to 87.2 per cent. The most rapid accumulation of alcohol-insoluble solids occurred between the first and the third stages of maturity. From the third stage to the fifth stage, the rate of accumulation was retarded until the maximum amount was found in the fifth stage. After this there occurred a slight decrease; however, it did not prove to be significant.

The increase in the alcohol-insoluble solids of southern peas with maturity was highly significant (Table 4a). This was due mainly to the wide variations among the first three stages of maturity, since the L.S.D. (Table 4) indicated that there were no significant differences among the last three stages. The period of slow accumulation in the alcohol-insoluble solids which occurred after the third stage followed by a decrease between the last two stages probably caused the curvilinear regression line to form a better fit than the linear.

The Influence of Maturity Upon the Ascorbic Acid Content

Fresh Weight:- As the development of the seeds of southern peas proceeded, there was a decline in the ascorbic acid from 23.2 milligrams per 100 grams of seeds in the first stage of maturity to 6.5 milligrams per

TABLE 4

ALCOHOL-INSOLUBLE SOLIDS CONTENT OF SOUTHERN PEAS,
ON A DRY WEIGHT BASIS, HARVESTED AT
SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	68.61	73.83	79.70	74.05
2	80.23	76.53	81.17	79.31
3	86.33	85.23	82.95	84.84
4	85.08	88.64	85.78	86.48
5	88.85	93.46	88.35	90.22
6	88.65	86.80	86.19	87.21
Means for Plantings	82.95	84.08	84.02	

L.S.D. for Stage of Maturity Means .05 = 5.592

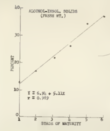
L.S.D. for Stage of Maturity Means .01 = 7.954

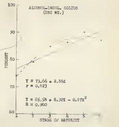
L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.823

Curvilinear Correlation Coefficient = 0.900

Figure 2. The linear and curvilinear relationships of alcohol-insoluble solids, on fresh and dry weight bases, to maturity of southern peas.


ALCOHOL-INSOL. SOLIDS
(FRESH WT.)
40
30
20
10
0
PERCENT
Y = 6.94 + 5.11X
r = 0.989
1
2
3
4
5
6
STAGE OF MATURITY


ALCOHOL-INSOL. SOLIDS
(DRY WT.)
100
90
80
70
60
PERCENT
Y = 73.66 + 2.86X
r = 0.823
Y = 65.58 + 8.92X - 0.87X²
R = 0.900
1
2
3
4
5
STAGE OF MATURITY

100 grams in the sixth stage (Table 5). When the mean values for the ascorbic acid were shown graphically (Figure 3), it was evident that there was a rapid decline between the first and second stage of maturity followed by a period of four days when the decrease in ascorbic acid was not so rapid. As soon as the pods began to lose their green color between the fourth and fifth stages of maturity, the ascorbic acid content commenced to decrease very rapidly in an almost straight line relationship and continued thus until the sixth stage of development.

Analysis of the data (Table 5a) shows that the decrease in ascorbic acid with maturity was highly significant. According to the L.S.D. (Table 5), the difference in ascorbic acid between the second and third stages was significant, but no significant difference existed between the third and fourth stages of development. Highly significant differences in ascorbic acid were found among all other stages of maturity. There was little departure of the ascorbic acid content of southern peas at different stages of maturity from linearity except in the fourth stage.

Dry weight.- There was a decrease in the ascorbic acid content of the seeds of southern peas with maturity from 135.03 milligrams per 100 grams of seeds in the first stage of development to 15.29 in the sixth stage. The largest decrease occurred during the two-day period between the first and second stages of maturity. Here approximately 34 per cent of the ascorbic acid was lost. About 89 per cent of the ascorbic acid was lost between the first and sixth stage of maturity. This represented an average decline of approximately 12 milligrams per 100 grams of dry seeds per day; however, this loss was not always evenly distributed between stages.

TABLE 5

ASCORBIC ACID CONTENT OF SOUTHERN PEAS, ON A FRESH WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	mg/100 g.	mg/100 g.	mg/100 g.	mg/100 g.
1	23.41	24.09	22.10	23.20
2	16.61	21.08	20.55	19.41
3	15.49	17.18	17.87	16.84
4	15.99	14.89	15.58	15.48
5	10.56	10.56	11.47	10.86
6	6.90	6.55	6.02	6.49
Means for Plantings	14.83	15.72	15.60	

L.S.D. for Stage of Maturity Means .05 = 2.283

L.S.D. for Stage of Maturity Means .01 = 3.248

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.971

Curvilinear Correlation Coefficient N.S.

TABLE 6

ASCORBIC ACID CONTENT OF SOUTHERN PEAS, ON A DRY WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	mg/100 g.	mg/100 g.	mg/100 g.	mg/100 g.
1	130.27	139.28	135.56	135.03
2	81.87	95.31	95.60	90.92
3	61.02	66.44	69.67	65.71
4	53.04	48.24	52.36	51.21
5	26.54	28.54	29.99	28.49
6	15.80	15.92	14.17	15.29
Means for Plantings	61.42	65.68	66.22	

L.S.D. for Stage of Maturity Means .05 = 6.822

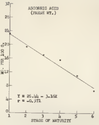
L.S.D. for Stage of Maturity Means .01 = 9.703

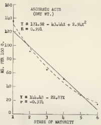
L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.974

Curvilinear Correlation Coefficient = 0.991

Figure 3. The linear and curvilinear relationships of ascorbic acid, on fresh and dry weight bases, to maturity of southern peas.


ASCORBIC ACID
(FRESH WT.)
32
28
24
20
16
12
8
4
0
MG. PER 100 G.
Y = 26.44 - 3.16X
r = -0.971
1
2
3
4
5
6
STAGE OF MATURITY


ASCORBIC ACID
(DRY WT.)
160
140
120
100
80
60
40
20
0
MG. PER 100 G.
Y = 171.92 - 43.44X + 2.94X²
R = 0.991
Y = 144.48 - 22.87X
r = -0.974
1
2
3
4
5
6
STAGE OF MATURITY

The variance in the ascorbic acid content attributed to maturity was highly significant (Table 6a). According to the L.S.D. (Table 6) the variations in ascorbic acid among all stages of maturity were highly significant. When the linear and curvilinear regression lines were fitted to the average ascorbic acid content at different stages of maturity, the curvilinear regression line formed the best fit (Figure 3). Nevertheless, there were no excessively large departures of the ascorbic acid content for any stage of maturity from linearity.

The Influence of Maturity Upon the Nicotinic Acid Content

Fresh Weight.- As the maturity of southern peas increased, there was no increase in nicotinic acid from 1.98 milligrams per 100 grams of seeds in the first stage of maturity to 2.40 milligrams per 100 grams of seeds in stage four (Table 7). During this period, the pods remained green in color. When the pods began to lose their green color between stages four and five, there followed a period of rapid decline in nicotinic acid which continued until only 1.43 milligrams per 100 grams of seeds remained in the sixth stage of maturity.

Analysis of the data (Table 7a) indicated that the variance associated with the maturity of southern peas was highly significant. However, according to the L.S.D. (Table 7) there were no significant differences among the second, third and fourth stages, nor between the second and fifth stages. When regression lines were fitted to the average nicotinic acid content at different stages of maturity (Figure 4), the curvilinear regression line gave the best fit. There were wide de-

TABLE 7

NICOTINIC ACID CONTENTS OF SOUTHERN PEAS, ON A FRESH WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	First mg/100 g.	Second mg/100 g.	Third mg/100 g.	Means for Stages mg/100 g.
1	2.19	1.72	2.04	1.98
2	2.28	2.07	2.39	2.18
3	2.25	2.02	2.37	2.21
4	2.45	2.37	2.40	2.41
5	1.95	2.06	2.03	2.01
6	1.30	1.30	1.69	1.43
Means for Plantings	2.07	1.92	2.12	

L.S.D. for Stage of Maturity Means .05 = 0.249

L.S.D. for Stage of Maturity Means .01 = 0.355

L.S.D. for Planting Means .05 = 0.176

Linear Correlation Coefficient = -0.451

Curvilinear Correlation Coefficient = 0.892

TABLE 8

NICOTINIC ACID CONTENT OF SOUTHERN PEAS, ON A
DRY WEIGHT BASIS, HARVESTED AT SIX
STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	mg/100 g.	mg/100 g.	mg/100 g.	mg/100 g.
1	12.6	10.5	11.5	11.53
2	10.8	9.5	10.6	10.30
3	8.7	7.8	10.1	8.87
4	8.0	7.9	7.9	7.93
5	5.1	5.4	5.2	5.23
6	3.0	3.0	4.0	3.33
Means for Plantings	8.03	7.35	8.22	

L.S.D. for Stage of Maturity Means .05 = 1.163

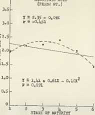
L.S.D. for Stage of Maturity Means .01 = 1.654

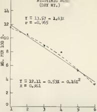
L.S.D. for Planting Means .05 = 0.822

Linear Correlation Coefficient = -0.965

Curvilinear Correlation Coefficient = 0.961

Figure 4. The linear and curvilinear relationships of nicotinic acid, on fresh and dry weight bases, to maturity of southern peas.


NICOTINIC ACID
(FRESH WT.)
Y = 2.35 - 0.09X
r = -0.451
Y = 1.41 + 0.61X - 0.10X²
R = 0.891
MG. PER 100 G.
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
1
2
3
4
5
6
STAGE OF MATURITY


NICOTINIC AC
(DRY WT.)
Y = 13.57 - 1.63X
r = -0.965
Y = 12.11 - 0.53X - 0.16X²
R = 0.961
MG. PER 100 G.
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
STAGE OF MATURITY

viations in the nicotinic acid content from linearity at various stages of maturity.

Dry Weight:- The nicotinic acid of southern peas decreased continuously from 11.53 milligrams per 100 grams in the first stage of maturity to 3.33 milligrams per 100 grams in the sixth stage (Table 8). This represented a loss of 70.8 per cent of the nicotinic acid between the first and sixth stage of maturity or an average of approximately 7.1 per cent per day.

The decrease in nicotinic acid of southern peas as a result of maturity was highly significant (Table 8a). There were highly significant differences in nicotinic acid among the last three stages of maturity (Table 8). Significant differences existed among the first three stages of maturity; however, there was no significant difference between stages three and four. Although the response of the nicotinic acid to maturity followed a somewhat curvilinear relationship, the departure from linearity was not great (Figure 4).

Influence of Maturity Upon the Protein Content

Fresh Weight:- The protein content of southern peas increased with maturity from 5.66 per cent in the first stage of maturity to 10.33 per cent in the sixth stage (Table 9). This constituted an increase of less than one-half per cent per day during the period between the first and last harvest. The increase in the per cent protein with maturity progressed rather slowly between the first and fourth stages of maturity; but, as the green color commenced to disappear from the pods, the per

TABLE 9

PROTEIN CONTENT OF SOUTHERN PEAS, ON A FRESH
WEIGHT BASIS, HARVESTED AT SIX
STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	6.17	5.57	5.25	5.66
2	5.83	6.62	6.28	6.24
3	6.79	7.38	6.91	7.02
4	7.78	8.06	7.38	7.74
5	9.28	8.76	9.25	9.10
6	10.42	10.14	10.42	10.33
Means for Plantings	7.71	7.75	7.58	

L.S.D. for Stage of Maturity Means .05 = 0.656

L.S.D. for Stage of Maturity Means .01 = 0.934

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.972

Curvilinear Correlation Coefficient = 0.982

cent protein began to increase more rapidly.

The increase of the protein content with maturity was highly significant (Table 9a). However, the difference in the protein content between stages one and two was non-significant as indicated by the L.S.D. (Table 9). The response of the protein content to maturity followed a curvilinear trend; nevertheless, the deviations from linearity at any stage of maturity was not large.

Dry Weight:- A relatively sharp decrease occurred between the first and second stages of maturity from 32.89 per cent in the first stage to 29.28 per cent in the second (Table 10). After this, there was an almost constant decline in the per cent protein until a low of 23.83 per cent remained in the fifth stage. A slight increase occurred between the fifth and sixth stages of maturity; however, this increase was not significant.

The variation in the protein content associated with maturity was highly significant (Table 10a). According to the L.S.D. (Table 10) there were no significant differences in the protein content among the last three stages. Because of the rapid decline in the protein content in the early stages of development followed by a period when the decrease was occurring at a slower rate, the curvilinear regression line gave the best fit. Relatively wide deviations from linearity occurred at different stages of maturity especially in the first and sixth stages.

TABLE 10

PROTEIN CONTENT OF SOUTHERN PEAS, ON A DRY WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	34.36	32.19	32.22	32.89
2	28.70	29.94	29.21	29.28
3	26.75	28.53	26.94	27.41
4	25.81	26.11	24.79	25.57
5	23.33	24.00	24.17	23.83
6	23.84	24.66	24.50	24.33
Means for Plantings	27.33	27.57	26.97	

L.S.D. for Stage of Maturity Means .05 = 2.519

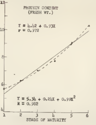
L.S.D. for Stage of Maturity Means .01 = 3.584

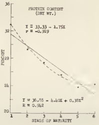
L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.929

Curvilinear Correlation Coefficient = 0.942

Figure 5. The linear and curvilinear relationships of the protein content, on fresh and dry weight bases, to maturity of southern peas.


PROTEIN CONTENT
(FRESH WT.)
Y = 4.42 + 0.93X
r = 0.972
Y = 5.34 + 0.24X + 0.99X²
R = 0.982
PERCENT
4
6
8
10
12
1
2
3
4
5
6
STAGE OF MATURITY


PROTEIN CONTENT
(DRY WT.)
Y = 33.33 - 1.75X
r = -0.929
Y = 36.85 - 4.40X + 0.38X²
R = 0.962
PERCENT
20
24
28
32
36
1
2
3
4
5
6
STAGE OF MATURITY

The Influence of Maturity Upon the Starch Content

Fresh Weight.- As the seeds of southern peas developed, the starch increased in an almost direct relationship from 4.97 per cent in the first stage of maturity to 19.94 per cent in the sixth stage (Table 11). This increase of starch with maturity represented approximately 1.5 per cent accumulation per day during the period between the first and sixth stages of maturity.

Analysis of the data (Table 11a) indicated that the increase in starch content with maturity was highly significant. A highly significant difference in starch content existed among all stages of maturity (Table 11). When a linear regression line was fitted to the mean of the starch content at different stages of maturity, a very good fit was found to exist (Figure 6).

Dry Weight.- The starch content of southern peas increased with maturity in a negative curvilinear trend from 29.2 per cent in the first stage of maturity to 48.0 per cent in the fifth stage. This was followed by a slight decrease between the fifth and sixth stages of maturity; however, this decrease was not significant (Table 12).

The variation in the starch content with maturity was highly significant (Table 12a). This was due mainly to the rapid accumulation of starch between the first and third stages of maturity; because, according to the L.S.D. (Table 12), there were no significant differences between the means of the third and fourth stages, nor among the last three stages of maturity. When linear and curvilinear regression lines were fitted to the mean of the starch content at different stages, the curvi-

TABLE 11

STARCH CONTENT OF SOUTHERN PEAS, ON A FRESH WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings First	Plantings Second	Plantings Third	Means for Stages
	%	%	%	%
1	4.62	5.21	5.07	4.97
2	8.18	8.21	8.27	8.22
3	11.44	11.81	11.20	11.48
4	13.52	14.14	13.80	13.82
5	18.57	17.65	18.29	18.17
6	20.01	19.69	20.11	19.94
Means for Plantings	12.72	12.76	12.79	

L.S.D. for Stage of Maturity Means .05 = 0.603

L.S.D. for Stage of Maturity Means .01 = 0.858

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.995

Curvilinear Correlation Coefficient N.S.

TABLE 12

STARCH CONTENT OF SOUTHERN PEAS, ON A DRY WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings First	Second	Third	Means for Stages
	%	%	%	%
1	26.1	30.1	31.3	29.2
2	40.3	37.1	38.5	38.6
3	45.0	45.7	43.7	44.8
4	44.8	45.8	46.3	45.6
5	46.7	48.4	48.8	48.0
6	45.8	47.8	47.3	47.0
Means for Plantings	41.4	42.3	42.6	

L.S.D. for Stage of Maturity Means .05 = 2.745

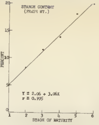
L.S.D. for Stage of Maturity Means .01 = 3.904

L.S.D. for Planting Means N.S.

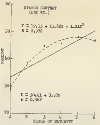
Linear Correlation Coefficient = 0.862

Curvilinear Correlation Coefficient = 0.974

Figure 6. The linear and curvilinear relationships of the starch content, on fresh and dry weight bases, to maturity of southern peas.



STARCH CONTENT
(FRESH WT.)
Y = 2.06 + 3.06X
r = 0.995
PERCENT
0
5
10
15
20
1
2
3
4
5
6
STAGE OF MATURITY



STARCH CONTENT
(DRY WT.)
Y = 19.13 + 11.82X - 1.21X²
R = 0.972
Y = 30.41 + 3.37X
r = 0.862
PERCENT
20
30
40
50
60
1
2
3
4
5
6
STAGE OF MATURITY

linear regression line gave the best fit. The response of the starch content to maturity varied widely from linearity (Figure 6).

Influence of Maturity Upon Reducing Sugar

Dry Weight.- Relatively little reducing sugar was found in southern peas of the variety used in this study (Table 13). There was a sharp decline in reducing sugar between the first and second stages of maturity from 1.78 to 0.87 per cent. This rapid decrease was followed by a more gradual decline after the third stage to 0.29 per cent in the last stage of development.

The variance in the reducing sugar attributed to maturity was highly significant (Table 13a); however, no significant difference was found among the last four stages of maturity. When linear and curvilinear regression lines were fitted to the mean reducing sugar content at different stages of maturity, the curvilinear regression line formed the best fit. This was due to the rapid decrease in reducing sugar in the first three stages of maturity followed by a period when the loss was more gradual. The reducing sugar content at different stages of maturity deviated widely from the linear regression line (Figure 7).

Influence of Maturity Upon the Total Sugar Content

Fresh Weight.- The total sugar content of southern peas decreased with maturity from 1.79 per cent in the first stage to a low of 1.38 per cent in the second. This decrease in total sugar between stages was and

TABLE 13

REDUCING SUGAR CONTENT OF SOUTHERN PEAS, ON A DRY WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	1.82	1.49	2.04	1.78
2	1.13	0.70	0.79	0.87
3	0.55	0.46	0.49	0.50
4	0.40	0.34	0.34	0.36
5	0.26	0.35	0.25	0.29
6	0.35	0.27	0.24	0.29
Means for Plantings	0.75	0.60	0.69	

L.S.D. for Stage of Maturity Means .05 = 0.261

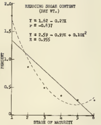
L.S.D. for Stage of Maturity Means .01 = 0.371

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.856

Curvilinear Correlation Coefficient = 0.955

Figure 7. The linear and curvilinear relationships of the reducing sugar, on a dry weight basis, to maturity of southern peas.



REDUCING SUGAR CONTENT
(DRY WT.)
Y = 1.62 - 0.27X
r = -0.837
Y = 2.59 - 0.99X + 0.10X^2
R = 0.955
PERCENT
2.0
1.5
1.0
0.5
0
1
2
3
4
5
6
STAGE OF MATURITY

two was followed by an increase in each succeeding stage, reaching 2.66 per cent in the sixth stage of development.

The variance in the total sugar content of southern peas as a result of maturity was significant (Table 14a). Nevertheless, according to the L.S.D. (Table 14), there were no significant differences in the total sugar among the first four stages of maturity. There were wide departures of the average total sugar content at different stages of maturity from linearity. The curvilinear regression line formed a much better fit than the linear (Figure 8).

Dry Weight.- A rapid decrease in the total sugar content of southern peas occurred between the first two stages of maturity, from 10.36 per cent in the first to 6.56 per cent in the second (Table 15). This represented a loss of approximately 36 per cent of the total sugar within a period of two days. After this sharp decline, there followed a period of leveling off which reached a low of 5.21 per cent in the fourth stage. A slight increase occurred between the fourth and sixth stages of maturity; however, this increase was not significant.

Analysis of the data (Table 15a) showed that the variation in the total sugar content with maturity was significant. This was due mainly to the wide variation between stages one and two, since the L.S.D. (Table 15) gave evidence that there were no significant differences in the total sugar content among the last four stages of maturity. The curvilinear regression line gave a much better fit than the linear. Wide deviations in the total sugar content from linearity were found to exist.

TABLE 14

TOTAL SUGAR CONTENT OF SOUTHERN PEAS, ON A FRESH WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	1.78	2.07	1.51	1.79
2	1.58	0.92	1.65	1.38
3	1.48	0.92	1.78	1.39
4	2.27	1.31	1.14	1.57
5	2.06	2.22	2.19	2.16
6	2.89	2.59	2.49	2.66
Means for Plantings	2.01	1.67	1.79	

L.S.D. for Stage of Maturity Means .05 = 0.669

L.S.D. for Stage of Maturity Means .01 = 0.952

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.607

Curvilinear Correlation Coefficient = 0.795

TABLE 15

TOTAL SUGAR CONTENT OF SOUTHERN PEAS, ON A DRY WEIGHT BASIS, HARVESTED AT SIX STAGES OF MATURITY, 1951

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
1	9.85	11.99	9.30	10.38
2	7.81	4.18	7.68	6.56
3	5.84	3.58	6.94	5.45
4	7.53	4.26	3.83	5.21
5	5.18	6.10	5.72	5.66
6	6.61	6.30	5.87	6.26
Means for Plantings	7.14	6.07	6.56.	

L.S.D. for Stage of Maturity Means .05 = 2.81

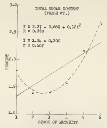
L.S.D. for Stage of Maturity Means .01 = 3.99

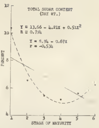
L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = -0.534

Curvilinear Correlation Coefficient = 0.795

Figure 8. The linear and curvilinear relationships of the total sugar content, on fresh and dry weight bases, to maturity of southern peas.


TOTAL SUGAR CONTENT
(FRESH WT.)
Y = 2.27 - 0.66X + 0.12X^2
R = 0.820
Y = 1.14 + 0.20X
r = 0.607
3.0
2.5
2.0
1.5
1.0
PERCENT
1
2
3
4
5
6
STAGE OF MATURITY


TOTAL SUGAR CONTENT
(DRY WT.)
Y = 13.66 - 4.21X + 0.51X^2
R = 0.794
Y = 8.94 - 0.67X
r = -0.534
12
10
8
6
4
PERCENT
1
2
3
4
5
6
STAGE OF MATURITY

Influence of Maturity Upon the Specific Conductance

The specific conductance of the juice of southern peas was determined for five stages of maturity (Table 16). It was found to increase almost directly with maturity from 1113 x 10^{-5} mhos in the first stage to 1450 x 10^{-5} mhos in the fifth stage of maturity. The specific conductance of the sixth stage was not measured.

The increase of the specific conductance with maturity was highly significant (Table 16a). According to the L.S.D. (Table 16), however, there was no significant differences in the specific conductance between the third and fourth stages. Although there were slight deviations in the specific conductance from linearity at different stages of maturity, these departures were fairly well distributed about the linear regression line (Figure 9).

Influence of Maturity Upon the Refractive Index

The refractive index of the juice of southern peas for the first and second stages of maturity was 1.347. Although the refractive index increased to 1.348 in the third stage of maturity, this increase was not significantly greater than for the first two stages. Beginning with the third stage, however, the refractive index began to increase and continued to do so with each succeeding stage, reaching 1.372 in the sixth stage of maturity (Table 17).

The variations in the refractive index associated with maturity were highly significant (Table 17a). This was due mainly to the wide

TABLE 16

SPECIFIC CONDUCTANCE OF THE JUICE EXTRACTED FROM
SOUTHERN PEAS HARVESTED AT FIVE
STAGES OF MATURITY, 1952*

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
1	1123	1096	1121	1113
2	1183	1183	1190	1185
3	1257	1270	1401	1309
4	1313	1327	1370	1337
5	1380	1497	1473	1450
Means for Plantings	1251	1275	1311	

L.S.D. for Stage of Maturity Means .05 = 68.2

L.S.D. for Stage of Maturity Means .01 = 92.4

L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.938

Curvilinear Correlation Coefficient N.S.

---

* Expressed as mhos x 10^{-5}

TABLE 17

REFRACTIVE INDEX OF THE JUICE OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, 1952

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
1	1.347	1.345	1.350	1.347
2	1.347	1.346	1.347	1.347
3	1.347	1.348	1.348	1.348
4	1.349	1.351	1.352	1.351
5	1.357	1.358	1.357	1.357
6	1.367	1.378	1.370	1.372
Means for Plantings	1.352	1.354	1.354	

L.S.D. for Stage of Maturity Means .05 = 0.0033

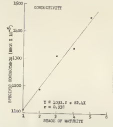
L.S.D. for Stage of Maturity Means .01 = 0.0091

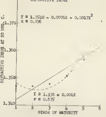
L.S.D. for Planting Means N.S.

Linear Correlation Coefficient = 0.838

Curvilinear Correlation Coefficient = 0.996

Figure 9. Linear and curvilinear relationships of the specific conductance and refractive index to maturity of southern peas.


CONDUCTIVITY
SPECIFIC CONDUCTANCE (MHOS X 10^-5)
1500
1400
1300
1200
1100
Y = 1031.2 + 82.4X
r = 0.938
1
2
3
4
5
6
STAGE OF MATURITY


REFRACTIVE INDEX
REFRACTIVE INDEX AT 20 DEG. C.
1.380
1.370
1.360
1.350
1.340
Y = 1.3540 - 0.0076X + 0.0017X^2
R = 0.996
Y = 1.338 + 0.004X
r = 0.875
1
2
3
4
5
6
STAGE OF MATURITY

differences that existed among the last three stages of maturity. There were no significant differences among the last three stages of maturity. When linear and curvilinear regression lines were fitted to the average refractive index of southern peas at different stages of maturity, the curvilinear regression line formed the best fit. The refractive index of the juice of southern peas departed quite widely from linearity (Figure 9).

Influence of Maturity Upon the Per Cent Seed Shellout

As the development of the seeds of southern peas continued, there was an increase in the per cent seed shellout from 25.6 per cent in the first stage of maturity to 75.7 per cent in the sixth stage (Table 18). With the approach of the sixth stage, there appeared to be a slight leveling off in the per cent seed shellout.

Analysis of the data (Table 18a) showed that there was a highly significant increase in the per cent seed shellout with maturity. Highly significant differences in the seed shellout existed between all stages of maturity as indicated by the L.S.D. (Table 18). Significant differences were also found among southern peas harvested from different planting dates. Linear and curvilinear regression lines were fitted to the average per cent seed shellout at different stages of maturity (Figure 10). Although there were some deviations from linearity, these departures were not large and gave a fairly good linear relationship between the per cent seed shellout and maturity.

TABLE 18

PER CENT SEED SHELLOUT OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, 1952

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
	%	%	%	%
1	24.62	26.60	25.55	25.59
2	33.33	35.07	35.69	34.70
3	42.74	47.35	46.11	45.60
4	53.52	62.76	62.78	59.69
5	65.57	70.11	69.50	68.39
6	69.91	79.11	78.11	75.71
Means for Plantings	48.20	53.60	52.96	

L.S.D. for Stage of Maturity Means .05 = 2.567

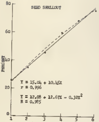
L.S.D. for Stage of Maturity Means .01 = 3.457

L.S.D. for Planting Means .05 = 3.945

Linear Correlation Coefficient = 0.996

Curvilinear Correlation Coefficient = 0.985

Figure 10, Linear and curvilinear relationships of the per cent seed shellout of southern peas to their maturity.


SEED SHELLOUT
80
60
40
20
0
PERCENT
1
2
3
4
5
6
STAGE OF MATURITY
Y = 15.04 + 10.45X
r = 0.996
Y = 12.08 + 12.67X - 0.32X²
R = 0.985

Influence of Maturity Upon the Specific Gravity of Southern Peas

Unblanched:- Southern peas in the first stage of maturity possessed a specific gravity of 0.995. This was followed by a decrease to 0.990 in the second stage of maturity (Table 19). Beginning with the second stage, the specific gravity began to increase and continued to do so with each succeeding stage of maturity, reaching a high of 1.055 in the sixth stage.

The variation in the specific gravity of southern peas associated with maturity was found to be highly significant (Table 19a). This was due mainly to the wide variations which existed among the last three stages of maturity. No significant difference in the specific gravity existed between the first and third stages of maturity. Highly significant differences in the specific gravity also existed among southern peas harvested from different planting dates (Table 19). The response of the specific gravity of unblanched southern peas to maturity departed widely from linearity (Figure 11).

Blanched:- The specific gravity of the seeds of southern peas increased almost directly with maturity from 1.024 in the first stage to 1.21 in the sixth stage. The most rapid increase occurred between the first and fourth stages (Table 20). After the fourth stage of development, there was a leveling off in the specific gravity.

An analysis of the data (Table 20a) showed that the variations associated with maturity were highly significant. The L.S.D. (Table 20) indicated that there were highly significant differences among all stages of maturity. There was relatively little deviation of the specific

TABLE 19

SPECIFIC GRAVITY OF UNBLANCHED SOUTHERN PEAS
HARVESTED AT SIX STAGES OF MATURITY, 1952

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
1	0.988	1.000	0.997	0.995
2	0.990	0.995	0.986	0.990
3	0.990	1.000	0.997	0.995
4	1.004	1.004	1.014	1.008
5	1.017	1.015	1.039	1.023
6	1.022	1.061	1.081	1.055
Means for Plantings	1.002	1.012	1.020	

L.S.D. for Stage of Maturity Means .05 = 0.0020

L.S.D. for Stage of Maturity Means .01 = 0.0027

L.S.D. for Planting Means .05 = 0.0031

L.S.D. for Planting Means .01 = 0.0051

Linear Correlation Coefficient = 0.795

Curvilinear Correlation Coefficient = 0.774

TABLE 20

SPECIFIC GRAVITY OF BLANCHED SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, 1952

Stage of Maturity	Plantings			Means for Stages
	First	Second	Third	
1	1.019	1.030	1.024	1.024
2	1.037	1.041	1.060	1.046
3	1.057	1.062	1.074	1.064
4	1.095	1.096	1.089	1.093
5	1.109	1.103	1.111	1.108
6	1.117	1.129	1.119	1.122
Means for Plantings	1.072	1.077	1.079	

L.S.D. for Stage of Maturity Means .05 = 0.0069

L.S.D. for Stage of Maturity Means .01 = 0.0093

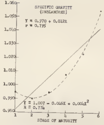
L.S.D. for Planting Means .05 = 0.0024

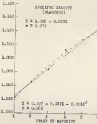
L.S.D. for Planting Means .01 = 0.0040

Linear Correlation Coefficient = 0.979

Curvilinear Correlation Coefficient = 0.982

Figure 11. Linear and curvilinear relationships of the specific gravity of blanched and unblanched seeds to their maturity.


SPECIFIC GRAVITY
(UNBLANCHED)
Y = 0.970 + 0.012X
r = 0.795
Y = 1.007 - 0.016X + 0.004X^2
R = 0.774
1.060
1.050
1.040
1.030
1.020
1.010
1.000
0.990
0.980
1
2
3
4
5
6
STAGE OF MATURITY


SPECIFIC GRAVITY
(BLANCHED)
Y = 1.006 + 0.020X
r = 0.979
Y = 0.997 + 0.027X - 0.001X^2
R = 0.982
1.160
1.140
1.120
1.100
1.080
1.060
1.040
1.020
1.000
1
2
3
4
5
6
STAGE OF MATURITY

gravity from linearity as the maturity of the seeds increased (Figure 11).

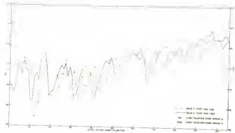
Growing Temperature and Time of Development

1951 Season.- The average temperature for the duration of this study in 1951 was 72.3° F. The mean daily temperature ranged from a low of 44.5° F on March 14 to a high of 84.0° F on June 10, 1951. The lowest temperature recorded in this study during 1951 was March 16 when the temperature dropped to 38° F. The highest temperature occurred June 5 at 90° F. The second and third plantings were the only ones affected by this high temperature as peas of the first planting were already harvested. The mean daily temperature is shown in Figure 12.

From the time of planting until the first harvest required 83 days and an average temperature of 69.3° F for the first planting made March 2, 79 days and 71.8° F for the second planting made March 23, and 73 days with an average temperature of 74.3° F for the third planting made April 5. The time required for southern peas to develop from flowering to the first stage of maturity was 12 days for the first planting, 10 days for the second, and 10 days for the third planting.

1952 Season:- The average daily temperature varied from 52.7° F to 86.5° F. The lowest temperature recorded was 34° F on the morning of March 17, before seedlings of the first planting had emerged. The temperature did not fall below 40° F at any time after the emergence of the first seedlings. The highest temperature was recorded on June 12, which was 101.5° F. However, since the first two plantings had already been harvested, the third planting was the only one affected by this high temperature. The average temperature for the first, second and third

Figure 12. The mean daily temperature for the period between the time of the first planting and the last harvest during the 1951 and 1952 season.


MEAN F TEMP FOR 1981
MEAN F TEMP FOR 1982
981 FIRST PLANTING MADE MARCH
1982 FIRST PLANTING MADE MARCH
DAYS AFTER FIRST PLANTING
0
10
20
30
40
50
60
70
80
90
100

planting from the time of the emergence of the seedlings to flowering was 67.2, 67.6 and 71.6 degrees F, respectively.

In the first planting, 71 days elapsed between the planting date and tagging of the flowers of the first flush of blooms. There were 59 days between the second planting and tagging of flowers, and 57 days for the third planting. From the time of the emergence of the seedlings from the soil until the flowers were tagged, 60 days were required for the first planting, 55 days for the second, and 50 days for the third. Nine days elapsed from the tagging of flowers until the first stage was harvested in the first and second planting, while 10 days were required for the third planting.

Organoleptic Examination

As shown in Table 21 and Figure 13, there was little difference in the general appearance between peas of the first four stages of maturity after they were frozen and cooked. The taste panel rated all of the first four stages as good; however, after the fourth maturity stage, the general appearance became poorer with the rating of only fair assigned them. There was no appreciable decrease in green color of the seeds of southern peas until after the fourth stage of maturity. After the fourth stage, there was a sharp decline in the green color. The texture was rated as declining slowly in value with each successive stage of maturity from the first through the sixth stage. However, there was no sharp break in texture of southern peas from one stage to another, as shown in Figure 13. In some instances, difference of opinions existed among the judges in

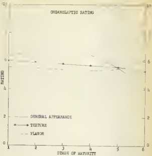
TABLE 21

THE AVERAGE ORGANOLEPTIC RATING OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY, BLANCHED THREE MINUTES, FROZEN AND EXAMINED BY TASTE PANEL

Stage of Maturity	General Appearance	Color	Texture	Flavor	Odor
1	6.4	6.8	6.0	5.5	5.3
2	6.7	7.0	5.9	5.6	5.7
3	6.9	6.6	5.8	5.3	5.7
4	6.5	6.7	5.7	5.2	6.1
5	4.8	5.2	5.6	5.5	6.5
6	4.1	4.5	5.3	6.4	6.7

* 0 - 4 Poor; 4 - 6 Fair; 6 - 8 Good; 8 - 10 Excellent.

Figure 13. Graphic analyses of the organoleptic rating of frozen southern peas harvested at six stages of maturity.



ORGANOLEPTIC RATING

their evaluation of flavor. As shown in Table 21 and Figure 13, the desired flavor decreased slightly from the first stage of development to the fourth stage; but it increased slightly after the fourth stage of maturity, reaching its highest value in the last stage of maturity. The characteristic odor of southern peas increased constantly from the first stage of maturity to the sixth stage. When all factors are considered, organoleptically, there was relatively little difference in the quality of southern peas of the first four stages of maturity; however, the last two stages of maturity were considered inferior. This lower rating of the last two stages of maturity was due mainly to the decrease in the general appearance, color and texture.

DISCUSSION OF RESULTS

The rate at which the physiological changes occurred in the seeds of southern peas during their growth and development was probably affected somewhat by the environmental conditions under which they were grown. During the months of May and June, 1951, when the seeds were developing and maturing, there was little change in the mean daily temperature. This probably accounted for the non-significant variations in the biochemical changes between planting dates for that year. In contrast, during the 1952 season a high temperature occurred during the latter part of the harvest season as compared to the lower mean temperature during the first half. This was probably responsible for the significant differences found in the specific conductance and the highly significant differences in moisture, per cent sand shellout, and specific gravity of southern peas harvested from different planting dates for that year. The influence of soil moisture upon the maturation processes was minimized through the use of irrigation to supplement the low rainfall which normally occurs during the season when the seeds are developing.

Conditions that accelerated or retarded the normal rate of formation and accumulation of materials in the seeds during development probably exerted an influence upon all of the physical and chemical changes, though not necessarily to the same degree. There was probably a movement of certain substances from the plant into the pods throughout the period that the pods remained green in color and the seeds were enlarging, but this ceased about the time the seeds reached their maximum size. Several factors probably affected the apparent physical and chemical changes that occurred in the seeds of southern peas during their development. The speed with which some changes appeared to occur were not altogether true changes, but instead, reflected the decrease in the moisture content and the increase in starch and other polysaccharides with maturity. Possibly one of the better examples of this was the increase of the protein content in the seeds during maturity on a fresh weight basis and the decrease when calculated on a dry weight basis.

As has been noted, the moisture content of southern peas appeared to be influenced somewhat by the environmental conditions under which they are grown. The average temperature was higher during the latter part of the harvest period of the 1951 season than for 1951. Consequently, as would be expected, the moisture content for the sixth stage of maturity of the second and third plantings in 1952 was lower than for the corresponding maturity stage and plantings of the 1951 season. Nevertheless, no large differences appear to have existed between the moisture content of southern peas grown during 1951 from corresponding stages in 1952. This is especially true for the first five stages of maturity.

From the results obtained in this study, it appears that the moisture content is a good index of maturity in southern peas. Moisture content has been considered as an index of maturity for some crops for a long time. Some investigators appear to rely on it as a means of determining maturity more than others. Kertesz (20) did not think that moisture content was very reliable as an index of maturity in English peas. Lee (23), on the other hand, stated that in lima beans moisture decreased with maturity with a corresponding increase in total solids and that either could be used to denote the stage of maturity as well as quality. Gould (16) thought that moisture content could be used for determining the optimum stage of maturity for harvesting green beans. Not only is the per cent moisture in the seeds of southern peas indicative of their stage of development, but the ease with which the moisture content can be determined makes it one of the more desirable methods for determining the stage of maturity.

As in other closely related crops of the Leguminosae family (4) (18) (21) (24), the alcohol-insoluble solids of southern peas increased in a direct relationship to maturity, on a fresh weight basis. It appears that alcohol-insoluble solids of southern peas, on a fresh weight basis, are quite indicative of the stage of maturity. However, when considered on a dry weight basis, only in the early stages of maturity could alcohol-insoluble solids be relied upon as an index of the stage of development. When the alcohol-insoluble solids (Figure 2) and starch (Figure 6) are compared, it can be readily observed that both increase in a parallel manner on both a fresh and dry weight basis. This gives further evidence that starch made up the greater portion of alcohol-insoluble solids of southern peas, and therefore, reflects as the amount of alcohol-insoluble solids found at different stages of maturity.

When southern peas are utilized at an early stage of development, they are a very good source of ascorbic acid. However, as the seeds approach a state of field dryness, there is little retention of this vitamin. Ascorbic acid could serve as an index of maturity, because of the wide variation in it between stages of maturity when calculated as a dry weight basis. Its relative speed and ease of determination also is an advantage. However, since ascorbic acid is quite labile under certain conditions, precautions should be taken to insure that the determinations are made immediately after the peas are harvested. In comparing the results of this study with those of Richardson _et al._ (30), their mean value of 53.3 milligrams of ascorbic acid per 100 grams of seeds on a dry weight basis was approximately the amount found in this study for maturity stage four. However, on a fresh weight basis, they reported 21.7 milligrams ascorbic acid per 100 grams of seeds. This would coincide with the mean value obtained between maturity stages one and two of this study.

The influence of maturity upon the nicotinic acid content, on a fresh weight basis, differed from that found for ascorbic acid. Southern peas in their earliest stages of development contained the highest amount of ascorbic acid, on a fresh weight basis, while maturity stage four possessed the largest amount of nicotinic acid. This increase in nicotinic acid in the first four stages of development, followed by a decline after the sixteenth day following flowering, paralleled somewhat the increase in the size of the seeds during their development and the loss of green color from the pods in the later stages of maturity. The average values for nicotinic acid obtained in this study appear to be slightly higher than those reported by Richardson _et al._ (30). There was, however, agreement in that the nicotinic acid, on a fresh weight basis, increased with maturity as long as the pods remained green. It appears that in order to derive the greatest benefit from southern peas with respect to nicotinic acid, they should be harvested not later than the sixteenth day after flowering. After the sixteenth day, the green color of the pods begins to disappear rapidly with a concomitant acceleration in the loss of nicotinic acid.

The per cent protein increased, on a fresh weight basis, from the first stage of maturity to the sixth stage. However, when calculated on a dry weight basis, there was a decrease with maturity. Neither the increase on a fresh weight basis nor the decrease with maturity on a dry weight basis, represented a great variation when compared with other compounds such as starch. It is possible that when the protein content was calculated on a fresh weight basis, the apparent increase did not represent an actual accumulation of protein, but, rather, was a percentage increase in the seeds due to the rapid loss of moisture from the peas. When the protein was calculated on a dry weight basis, the percentage decrease was probably caused by the rapid accumulation of starch and other polysaccharides in the seeds with maturity. The actual amount of protein contained in the seeds probably remained fairly constant. Protein content in southern peas reported in this study seems to compare favorably with the amounts reported by other investigators (26) (31) (32) (34) (39). Mitchel and Roderick (26) also found that there was very little change in protein content of southern peas at different stages of maturity.

Although the average protein content correlated well with maturity of southern peas, on both fresh and dry weight bases, it appears that the difference is not sufficient between stages of maturity to be of practical benefit for determining the stages of maturity by this means.

The starch content of southern peas of this study was comparable to that found by other investigators (26) (32). Mitchel and Roderick (26) reported that as southern peas matured there was an increase in the starch content. This was confirmed in this study. They reported an average of 20.55 per cent in the snap stage; however, they did not say whether this was for the seeds only or for the whole pod. This would be comparable to, but slightly less than the starch content found in this study for southern peas harvested 10 days after flowering. Mitchel and Roderick (26) further reported a rapid increase in starch after the snap stage to 46.06 per cent for green-shelled and 49.60 per cent for mature-shelled seeds. The results of this study confirm their findings that the starch accumulated very rapidly between the first stage of development and the fourth stage, followed by a leveling off in the later stages of maturity, on a dry weight basis.

Unlike the sugar content, there appeared to be relatively little variation in the starch content between samples of southern peas at the same stage of maturity harvested on different days. This could indicate that once starch had been deposited in the seeds, there was little net conversion of the starch to sugar.

Starch, on a fresh weight basis, appears to be a good indication of the stage of development of the seeds from the time they can be separated from the pericarp until all green color disappears from the pods. In comparison, starch calculated on a fresh weight basis appears to be a much better indicator of the stage of maturity than when calculated on a dry weight basis. However, as may be noted in Figure 6, starch calculated on a dry weight basis increases linearly for the period between the tenth and fourteenth days after flowering and may be utilized fairly successfully as an index of maturity during this period.

A decrease in the average total soluble sugar content, on a dry weight basis, occurred during the development of the seeds until a minimum point was reached about the time they ceased to enlarge. This was just before the green color of the pods began to disappear rapidly. From the graphic analyses shown in Figures 6 and 8, it can be seen that this decrease in sugar was accompanied by a rapid increase in starch, on a dry weight basis, during the same period of growth. The variation in starch content among samples for any stage of maturity was not great, but sugar samples varied almost as widely for any stage of maturity as between stages.

The wide variations in the amount of total sugar between samples of the same stage of maturity harvested on different days could not possibly be accounted for in the rise and fall of starch for the corresponding periods. Therefore, it appears that although starch was the principal compound involved in the inter-conversion of sugar, it was by no means the only one included in this transition process. It appears that a rapid conversion of the sugars to other compounds took place under optimum conditions for such a process. Apparently, there were relatively high accumulations of sugar in the seeds of southern peas under certain conditions. However, the sugar did not appear to remain as such for long periods of time, but probably was converted to other compounds. Sucrose was the principal sugar found in southern peas while there was relatively little reducing sugar except in the very earliest stages of development. The sugar content did not appear to be indicative of the stage of development of the seeds except possibly in the very earliest stages. Even in the earliest stages, its reliability for such a purpose would be highly questionable on either a fresh or dry weight basis. The reducing sugar content of southern peas is equally unreliable as an index of maturity.

Some difficulty was encountered in obtaining enough juice from the seeds of southern peas to make the specific conductance determinations. Therefore, the use of specific conductance as an index of maturity appears to be somewhat impractical because of this fact. This difficulty was partly overcome by freezing the peas and extracting the juice after thawing. Since there was no significant difference in the specific conductance between the third and fourth stages of maturity, its reliability for determining maturity between these stages is questionable.

A comparison of the moisture content and specific conductance at various stages of maturity shown in Figures 1 and 9 indicates that when their average values were plotted graphically, the respective regression lines followed an inverse relationship. It is possible that the increase in specific conductance, especially in the later stages of maturity, was due more to the increased concentration of the electrolytes caused by the loss of moisture from the seeds with maturity than to the movement of electrolytes into the seeds as they matured.

Since there were no significant differences in the refractive index among the first three stages of maturity of southern peas, it does not appear to possess any practical value for determining maturity during the early stages of development. However, the refractive index was somewhat indicative of the stage of maturity in the last three stages.

The characteristic of air bubbles being adsorbed on the seeds of the first three stages of maturity caused doubt as to the reliability of specific gravity as an index of maturity of unblanched southern peas. However, as may be noted in Figure 11, a fairly good linear relationship existed between specific gravity and the last three stages of maturity of unblanched peas. Therefore, this test could be used to some extent for determining maturity of the more mature unblanched southern peas if certain precautions were followed such as timing the weighing of the peas after they had been lowered into the liquid medium.

The problem of gas bubbles being adsorbed on the seed is not confined to southern peas alone. Culpepper and Magruder (11) found that the correlation of the specific gravity of the fresh lima bean seeds with maturity was extremely poor until the seed coats were removed. Then the correlation was very good. They attributed this to the fact that air was trapped beneath the seed coats and between the cotyledons. In the case of southern peas, the difficulty in determining specific gravity was probably due in part to air beneath the seed coat, but it was also a surface-adsorption phenomenon as well. Industry has long used brine solutions of different specific gravity for separating over-mature lima beans from the more tender beans. It has partly overcome the gas bubble problem by a system of agitation which removed some of the gas bubbles from the surface of the seeds. It is very likely that this system would work equally well for southern peas.

The specific gravity of the blanched seeds showed promise as a means for determining the maturity of southern peas. As may be noted in Figure 11, a good linear relationship existed between the specific gravity of blanched southern peas at different stages of maturity. Although the gas bubbles adsorbed on the seeds while in the weighing medium pose a problem which must be considered in this determination, it is by no means as great as in the unblanched seeds. The use of specific gravity for determining the maturity of southern peas has the advantage that it is a determination which is easy to make and relatively rapid. If the precautionary measure of weighing the seeds in the weighing medium at exactly 30 seconds after they are lowered into the liquid is followed, good precision can be obtained by this method of determining maturity in southern peas.

Because of the rapid growth and development of the seeds, the per cent seed shellout proved to be one of the best tests for determining quality and maturity of southern peas. To add to its possibilities as an index of maturity, it is one of the easiest and fastest determinations of this type that can be made. The Food and Dry Administration and certain investigators (16) have long recognized the use of the per cent seed shellout in green beans to denote maturity and quality. It appears that if southern peas were harvested when their per cent seed shellout was between 5½ and 6½ per cent, they would be within the range of optimum maturity that would give maximum yield and still possess good quality. According to Gould (16), green beans with 8.1 to 16.0 per cent seed are at optimum maturity to give a good quality fresh, frozen or canned product.

It appears that the more promising objective methods for the evaluation of quality and maturity of southern peas are the per cent seed shellout, moisture content, alcohol-insoluble solids, and starch content, all on the fresh weight basis. The alcohol-insoluble solids content seems to be a more practical indicator of the stage of maturity of southern peas than starch due to the fact that it is an easier and more rapid determination to make.

Southern peas had a relatively short period of time in which they were desirable for use as a fresh product after they reached the stage where it is economically feasible to harvest them for food. It required only 10 days from the time the seeds could be separated from the pericarp in the first stage of maturity until all green color had completely disappeared from the pods. From the first stage of maturity, approximately 10 days after flowering, until the sixteenth day after flowering, there was a rapid increase in the size of the seeds concomitant with a rapid increase in the dry matter. This increase in the per cent dry matter can be accounted for largely by the rapid accumulation of polysaccharides which occurred during this period accompanied by a loss of moisture from the seeds. Since the seeds continued to enlarge until approximately six days after the seeds could be separated from the pericarp and since the quality of the frozen product decreased rapidly after this period, it appears that not more than two days are available to harvest southern peas in order to get maximum yield and still retain quality.

The results of a taste panel as utilized in this study are sometimes misleading and can never be construed as the final authority as the quality of a food product. Among some of the main disadvantages in relying on the organoleptic examination alone as an evaluation of quality are the chances for a biased estimate due to previous experience with certain foods, the small a group to represent a cross section of consumers, and the lack of training on the part of the members of the taste panel for making the evaluations. Because of these as well as other factors, objective as well as subjective methods of evaluation should be employed to determine quality.

There appears to be no advantage in harvesting southern peas before the fifteenth or sixteenth day after flowering except when emphasis is placed on the vitamin content. If they were harvested before this date, it would be at a sacrifice of yield, because there was no enlargement of the seeds until about the sixteenth day after flowering with a consequent increase in yield. If peas are harvested after the sixteenth day, not only is there a sacrifice of yield with each succeeding day, but there is also a decrease in quality. According to the results of the taste panel given in Table 21 and Figure 13, there was no great difference in the rating of southern peas at different stages of maturity until after the fourth stage of development. After the fourth stage, there was a decrease in quality as the maturity increased.

SUMMARY AND CONCLUSIONS

A study was made to determine and correlate certain physical and chemical measurements with maturity of the southern pea, *Vigna sinensis*. The California Blackeye No. 5 variety was used. Seeds were planted on three different dates at intervals of two weeks during 1951 and 1952. Samples were harvested at six different stages of maturity. Those representing the first stage of maturity were harvested as soon as the seeds could be separated from the pericarp, approximately 10 days after flowering. Further harvests were made at two-day intervals thereafter until the sixth or final stage was harvested. Samples for the different physical and chemical determinations were prepared immediately after the peas were harvested. Samples for the organoleptic test representing the different stages of maturity were shelled, blanched in boiling water for three minutes, cooled, and frozen at 0° F. After approximately six months, the organoleptic examinations were made to determine which stage or stages were best suited for freezing. Efforts were made to determine the reliability of certain physical and chemical measurements as indices of maturity and quality of southern peas.

The moisture content of southern peas decreased in a linear relationship with maturity and appeared to be a good index of the stage of development. Although the temperature probably had some effect upon the moisture content, it did not seem to adversely affect its reliability as an index of maturity.

The alcohol-insoluble solids of southern peas increased linearly, with maturity, on a fresh weight basis, and appeared to be a satisfactory indicator of the stage of maturity.

Southern peas are a very good source of ascorbic acid if utilized in the early stages of maturity. However, as the maturity increased, there was a rapid decrease in ascorbic acid until little remained in the sixth stage of development, 20 days after flowering. A good correlation existed between ascorbic acid and maturity of southern peas, on both fresh-weight and dry-weight bases. Therefore, the ascorbic acid content can be used satisfactorily as an index of maturity if the determinations are made immediately after the peas are harvested.

Southern peas contained the highest amount of nicotinic acid, on a fresh weight basis, in the fourth stage of maturity, 16 days after flowering. On a dry weight basis, the largest amount was in the first stage of development and decreased with each succeeding stage.

There was a rapid increase in the size of the seeds concomitant with a rapid increase in dry matter during their development. This increase in dry matter was largely due to the rapid accumulation of polysaccharides composed chiefly of starch.

Although there was a slight increase in the per cent protein in southern peas on a fresh weight basis, and a percentage decrease when calculated on a dry weight basis, there was relatively little change in the absolute protein content during their maturing process.

The starch content of southern peas increased directly with maturity, on a fresh weight basis, and was very indicative of the stage of development. In the older stages, starch made up almost one-half of the total dry matter.

The total soluble sugar content decreased with maturity until a minimum point was reached in the fourth stage of development. There was very little linear correlation between the maturity of southern peas and their sugar content. Sucrose was the principal soluble sugar found in southern peas, and there was relatively little reducing sugar except in the very earliest stages of development. The sugar content did not appear to be a useful indicator of the stage of maturity.

The specific conductance increased with maturity in the first five stages of development causing a good linear correlation to be established. This increase was probably due mainly to the increased concentration of electrolytes as a result of the loss of moisture from the seeds with maturity. If the juice could be extracted quickly and efficiently from the seeds, this measurement would probably be adapted to determining the stage of development of southern peas.

There were no significant differences in the refractive index among the first three stages of maturity of southern peas; however, there was an increase with maturity in the last three stages. This measurement does not appear to be adapted to determining maturity in southern peas.

The per cent seed shellout of southern peas increased directly with maturity and appeared to be one of the best tests for determining the stage of maturity. In addition to its reliability as an index of maturity, the per cent seed shellout was one of the easiest and fastest determinations of this type that was made.

Air bubbles adsorbed on the surface of the seeds of southern peas caused doubt as to the reliability of specific gravity as an index of maturity. The problem of air bubbles adsorbed on the seeds was not as great after the seeds were blanched as before blanching. Results show that if the seeds were blanched three minutes, cooled, and their weights taken at exactly 30 seconds after being lowered into the weighing medium, the apparent specific gravity increased directly with maturity and gave a very good linear correlation coefficient.

Some of the more promising objective methods used for determining the quality and maturity of southern peas in conjunction with the organoleptic examination were the per cent seed shellout, moisture content, alcohol-insoluble solids content, and starch content, all on fresh weight basis.

Southern peas had a relatively short period of time in which they were desirable for use as a fresh product after they reached the stage where it is economically profitable to harvest them for food. The best time to harvest southern peas appears to be between the fifteenth and seventeenth day after flowering. At this stage of maturity their moisture content was 65 to 70 per cent; the per cent seed shellout 54 to 64 per cent; and alcohol-insoluble solids and starch contents, on a fresh weight basis, 23 to 30 per cent and 12 to 15 per cent, respectively.

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APPENDIX

TABLE 1a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN MOISTURE CONTENT THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY DURING THE YEAR, 1951

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.65	---
Maturity Stages	5	285.86	249.87**
M_1 (Linear)	1	1411.03	1233.42**
M_q (Curvilinear)	1	8.90	7.77*
Deviation from quadratic	3	3.13	2.74
Error	10	1.144	---

TABLE 8a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE MOISTURE CONTENT OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY DURING THE YEAR, 1952

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	37.43	39.82**
Blocks	2	1.56	——
M.P. Error	4	0.94	
Subplots:			
Maturity Stages	5	1357.65	822.82**
M_L (Linear)	1	6621.39	4012.96**
M_Q (Curvilinear)	1	136.91	82.97**
Deviation from Quadratic	3	9.98	6.05**
M.S. x P.D.	10	14.46	8.76**
Subplot Error	30	1.65	——

TABLE 3a

THE ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN ALCOHOL-INSOLUBLE SOLIDS CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS DURING THEIR DEVELOPMENT

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	4	0.26	—
Maturity Stages	5	227.83	305.98**
M_1 (Linear)	1	1370.27	1509.11**
M_q (Curvilinear)	1	1.08	1.20
Deviation from Quadratic	3	5.93	6.53**
Error	10	0.908	—

TABLE 4a

THE ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN ALCOHOL-INSOLUBLE SOLIDS CONTENT, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS DURING THEIR DEVELOPMENT

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	2.44	—
Maturity Stages	5	105.79	10.46**
M_1 (Linear)	1	430.34	42.56**
M_q (Curvilinear)	1	83.99	8.30**
Deviation from Quadratic	3	4.68	—
Error	10	10.11	—

TABLE 5a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN ASCORBIC ACID CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS DURING THEIR DEVELOPMENT

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	1.42	——
Maturity Stages	5	107.41	66.41**
M_1 (Linear)	1	523.86	333.66**
M_q (Curvilinear)	1	4.45	2.83
Deviation from Quadratic	3	2.91	1.85
Error	10	1.57	——

TABLE 6a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN ASCORBIC ACID CONTENT, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	41.53	2.94
Maturity Stages	5	5741.67	407.78**
M_1 (Linear)	1	27454.18	1986.93**
M_q (Curvilinear)	1	965.77	68.59**
Deviation from Quadratic	3	96.14	16.53**
Error	10	14.08	——

TABLE 7a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN NICOTINIC ACID CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.060	3.16
Maturity Stages	5	0.336	17.52**
M_1 (Linear)	1	0.405	21.32**
M_q (Curvilinear)	1	1.123	59.10**
Deviation from Quadratic	3	0.051	2.68
Error	10	0.019	---

TABLE 8a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN NICOTINIC ACID CONTENT, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	1.25	3.06
Maturity Stages	5	28.71	70.19**
M_1 (Linear)	1	139.89	342.03**
M_q (Curvilinear)	1	2.52	6.16*
Deviation from Quadratic	3	0.39	---
Error	10	0.41	---

TABLE 9a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN PROTEIN CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.049	—
Maturity Stages	5	9.344	71.68**
M_1 (Linear)	1	45.054	345.77**
M_q (Curvilinear)	1	0.849	6.52*
Deviation from Quadratic	3	0.272	—
Error	10	0.130	—

TABLE 10a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN PROTEIN CONTENT, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.60	—
Maturity Stages	5	35.60	55.62**
M_1 (Linear)	1	160.20	250.31**
M_q (Curvilinear)	1	16.10	25.15**
Deviation from Quadratic	3	0.57	—
Error	10	0.64	—

TABLE 11a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN STARCH CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.01	—
Maturity Stages	5	98.92	899.27**
M_1 (Linear)	1	491.00	4463.63**
M_q (Curvilinear)	1	0.34	—
Deviation from Quadratic	3	1.09	9.99**
Error	10	0.11	—

TABLE 12a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN STARCH CONTENT, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	2.53	—
Maturity Stages	5	154.27	67.90**
M_1 (Linear)	1	595.85	261.30**
M_q (Curvilinear)	1	163.52	71.75**
Deviation from Quadratic	3	4.25	—
Error	10	2.28	—

TABLE 13a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN REDUCING SUGAR, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.034	—
Maturity Stages	5	1.074	51.90**
M_L (Linear)	1	3.773	182.29**
M_Q (Curvilinear)	1	1.180	57.04**
Deviation from Quadratic	3	0.139	6.73**
Error	10	0.020	—

TABLE 14a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN TOTAL SUGAR CONTENT, ON A FRESH WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	0.176	—
Maturity Stages	5	0.748	5.53*
M_1 (Linear)	1	0.530	3.91
M_q (Curvilinear)	1	0.432	3.19
Deviation from Quadratic	3	0.927	6.85**
Error	10	0.135	—

TABLE 15a

ANALYSIS OF VARIANCE TEST FOR THE CHANGES IN TOTAL SUGAR, ON A DRY WEIGHT BASIS, THAT OCCURRED IN THE SEEDS OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Planting Dates	2	1.716	—
Maturity Stages	5	11.119	4.66*
M_1 (Linear)	1	17.458	7.31*
M_q (Curvilinear)	1	28.677	12.02**
Deviation from Quadratic	3	3.153	—
Error	10	2.385	—

TABLE 16a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE CONDUCTIVITY OF THE JUICE EXTRACTED FROM SOUTHERN PEAS HARVESTED AT FIVE STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	1.360	6.65*
Blocks	2	0.191	—
M.P. Error	4	0.177	—
Subplots:			
Maturity Stages	4	16.215	98.99**
M_L (Linear)	1	61.36	374.60**
M_Q (Curvilinear)	1	0.02	—
Deviation from Quadratic	2	0.74	4.51*
M.S. x P.D.	8	0.505	3.08*
Subplot Error	24	0.163	—

TABLE 17a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE REFRACTIVE INDEX OF THE JUICE EXTRACTED FROM SOUTHERN PEAS HARVESTED AT SIX SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	0.2623	——
Blocks	2	0.0024	——
M.P. Error	4	0.2178	——
Subplots:			
Maturity Stages	5	8.3256	207.62**
M_1 (Linear)	1	31.000	773.10**
M_q (Curvilinear)	1	9.91	247.10**
Deviation from Quadratic	3	0.24	5.98**
M.S. x P.D.	10	0.1916	4.79**
S.P. Error	30	0.0401	——

TABLE 18a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE PER CENT SEED SHELLOUT OF SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	151.48	25.00**
Blocks	2	6.88	---
M.P. Error	4	6.06	---
Subplots:			
Maturity Stages	5	3468.51	1463.51**
N_1 (Linear)	1	17202.00	7258.51**
N_2 (Curvilinear)	1	33.78	14.25**
Deviation from Quadratic	3	35.59	15.02**
M.S. x P.D.	10	11.38	4.80**
S.P. Error	30	2.37	---

TABLE 19a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE SPECIFIC GRAVITY OF UNBLANCHED SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	1.327	34.92**
Blocks	2	0.054	---
M.P. Error	4	0.038	---
Subplots:			
Maturity Stages	5	5.414	360.93**
M_L (Linear)	1	21.660	1444.00**
M_Q (Curvilinear)	1	5.310	354.00**
Deviation from Quadratic	3	0.030	---
M.S. x P.D.	10	0.454	30.26**
S.P. Error	30	0.015	---

TABLE 20a

ANALYSIS OF VARIANCE (SPLIT-PLOT) TEST FOR THE EFFECT OF MATURITY UPON THE SPECIFIC GRAVITY OF BLANCHED SOUTHERN PEAS HARVESTED AT SIX STAGES OF MATURITY

Source of Variance	D.F.	Mean Square	F Value
Main Plots:			
Planting Dates	2	236.0	104.8**
Blocks	2	6.5	---
M.P. Error	4	2.2	---
Subplots:			
Maturity Stages	5	12732.0	732.7**
M_l (Linear)	1	62900.0	3614.9**
M_q (Curvilinear)	1	332.0	19.1**
Deviation from Quadratic	3	142.7	8.2**
M.S. x P.D.	10	146.6	8.4**
Subplot Error	30	17.4	---

BIOGRAPHICAL SKETCH

MAURICE W. HOOVER was born at Wrightsville, Georgia, December 15, 1916. Upon completion of his secondary education at the Wrightsville Public School in 1936, he entered Abraham Baldwin Agricultural College at Tifton, Georgia.

After serving six years, beginning June, 1940, in the United States Coast Guard, he was honorably discharged from the service on June 28, 1946. Following his discharge from the service, he entered the University of Florida, Gainesville in the summer of 1946, and graduated June 9, 1948 with the degree of Bachelor of Science in Agriculture, with honors.

In January, 1948, he became a member of the Alachua High School Faculty, Alachua, Florida, serving in the capacity of Teacher of Vocational Agriculture.

He received a Master of Science in Agriculture degree in January, 1950. In July of that same year, he obtained a leave of absence from the Alachua County Board of Public Instructions to continue further graduate study at the University of Florida, majoring in the field of Horticulture.

He was married to Rhea Margaret Leonard of Baltimore, Maryland, July 15, 1942.

He is a member of the Alpha Gamma Rho social fraternity. While in attendance at the University of Florida, he was elected to membership in the Honorary Fraternities of Phi Kappa Phi, Sigma Xi, Alpha Zeta, and Alpha Tau Alpha.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of the committee. It was submitted to the Graduate Council and was approved as partial fulfilment of the requirements for the degree of Doctor of Philosophy.

August 10, 1953

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